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AUTHOR Chiu, Chiung-Hui; Wu, Wei-Shuo; Huang, Chun-Chieh
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ABSTRACT

This paper reports on a study that investigated group learning processes in computer-supported collaborative concept mapping. Thirty 5th grade Taiwanese students were selected to attend a computer-mediated collaborative concept mapping activity. Dialog messages and map products tracked and recorded by the mapping system were analyzed. The exchanges in the dialog data were divided into four groups: opening a discussion; introducing a concept; establishing a link; and reconsidering the map. According to the analysis of the students' discourse record and group concept maps, it was found that the students took different approaches to develop their group concept maps. Four patterns of the computer-mediated collaborative concept mapping processes were identified: concept introduction first; limited concept introduction; less link establishment; and proposition construction oriented. In addition, different collaborative mapping approaches generated different concept maps. The findings suggest that students in a computer-mediated collaborative concept mapping activity should be guided or instructed to undertake some particular approach to generate satisfactory maps. (Contains 13 references.) (Author/MES)

Collaborative Concept Mapping Processes Mediated by Computer

Chiung-Hui Chiu, Wei-Shuo Wu, Chun-Chieh Huang
Institute of Computer and Information Education, National Tainan Teachers College,
33, Sec 2, Su-Lin Street, Tainan, Taiwan, Republic of China

Abstract: This paper is a report on a study, which investigated group learning processes in computer supported collaborative concept mapping. Thirty 5th grade Taiwanese students were selected to attend a computer mediated collaborative concept mapping activity. According to the analysis of the students' discourse record and group concept maps, it was found that the students took different approaches to develop their group concept maps. In addition, different collaborative mapping approaches generated different concept maps. The findings suggest that students in a computer mediated collaborative concept mapping activity should be guided or instructed to undertake some particular approach to generate satisfactory maps.

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Background

Concept mapping is a technique for representing knowledge in network graphs. Knowledge graphs consist of nodes and links. Nodes represent concepts and links represent the relationships between concepts (Novak & Gowin, 1984). Through the construction of a concept map (the integration of new related concepts, establishment of new links, or re-arrangement of existing concepts and links) learning can be assisted. In a meta-analysis of 19 quantitative studies, Horton, McConney, Gallo, Woods, Senn, & Hamelin (1993) reported that concept mapping generally had a positive effect on both knowledge attainment and attitude. Traditionally, concept mapping was carried out using paper and pencil. With that approach, two problems usually are encountered. First, students often need to spend significant amounts of time and effort revising and maintaining concept maps, with the result that many students may not concentrate on the body of knowledge. Second, teachers must spend considerable time and effort evaluating each student's concept map. These problems cause the overall concept mapping effect to suffer. The personal computer is now being used to support concept mapping and several supporting systems have been developed (Fisher, 1990; Kozma, 1987; Kozma & Van Roekel, 1986). It is generally agreed that assisted by computers, students can more easily construct, modify, or maintain their concept maps, and teachers can more efficiently evaluate students' concept maps (Reader & Hammond, 1994).

Concept mapping is usually integrated into cooperative learning activities. Participants are arranged into 3~5 person groups, and collaboratively construct their group concept maps. Although few studies have investigated the effects of collaborative concept mapping, most of the studies have found that collaborative concept mapping can lead to effective discussions concerning concepts, and thus enhance meaningful learning (Okebukola & Jegede, 1989; Roth & Roychoudhury, 1994). With the advancement of network technology, computers can also be used to support collaborative concept mapping just as computers support individual concept mapping. Interconnected computers, digital networks, and the World Wide Web (WWW) make collaborative concept mapping feasible even though the attendants are distributed (Chung, O'Neil, Herl, & Dennis, 1997).

Although the implementation of computers to support collaborative concept mapping has been experimental thus far, it is foreseeable that this application will gradually become practical and even widespread. This is evident by the fact that some organizations have made investments into the research and development of such computer systems. Therefore, it is necessary to investigate learning using computer mediated collaborative concept mapping. This approach may be very innovative from learning in traditional collaborative or computer aided individual concept mapping. In order to examine this the issues of this subject in depth, this study investigated the processes and patterns of students collaboratively developing concept maps in a networked environment. What processes they used to accomplish the concept mapping tasks and how these processes influenced their mapping outcomes were examined. This study not only provides a better understanding of the essentials of computer mediated collaborative concept mapping, but also provides directions for the design and improvement of this activity and its supporting network system.

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Methodology

In order to determine what processes characterize computer mediated collaborative concept mapping and how the processes influence the group map production, this study first modified a computer system we developed earlier (Chiu, Huang, & Chang, 2000) to support collaborative concept mapping. Second, primary students were selected to participate in a computer mediated collaborative concept mapping activity.

Subjects

Thirty 5th grade students in Taiwan attended this study. They had one-year of formal education in computer basics and applications. They were able to use a simple word processor, a painter, and an Internet browser. Before this activity, students were provided training to experience paper-and-pencil based concept mapping both individually and collaboratively.

Computer Supported Collaborative Concept Mapping System

The computer supported collaborative concept mapping system was implemented on the WWW platform. Group participants, even though distributed at different sites, could make use of this system to jointly construct their concept maps by connecting to the Internet and using a web browser (such as Internet Explorer). This system included three main modules. Figure 1 presents its architecture.

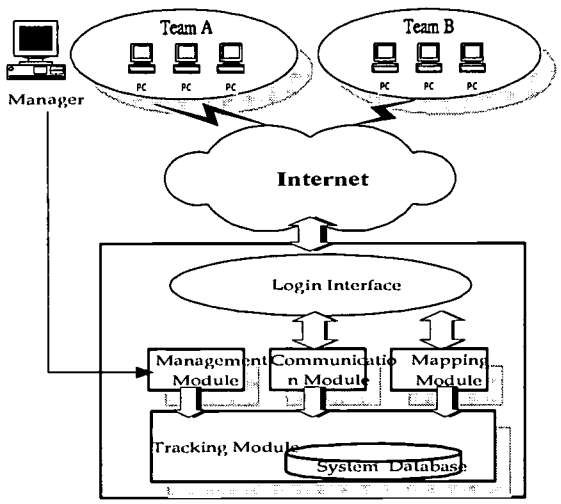

Figure 1: Shows architecture of computer supported collaborative concept mapping system.

Mapping Module

This module provided each group with functions to construct, modify, and reconstruct a concept map. Group members could view the same map on their individual computer screens. However, to avoid possible chaos in the group and concurrent problems in the system due to member cooperation, the mapping control was given to one member. Further, according to suggestions by Chung et al. (1997), this control was fixed to one member and not rotated. The mapping controller could add or delete a concept node and a relation link to the concept map via menu selections or move a concept node or a relation link by towing a mouse around. Once changes occurred, every member's computer screen would be updated.

Communication Module

This module also provided each group a text-based chat-room. This chat-room was used as a synchronous communication facility. Group members could type messages on individual computers to discuss and reason about their group concept map and then make decisions for any changes. Considering the slow typing problem which normally occurs among primary students, this system further designed quick-input mechanics for those frequently occurring messages (12 messaged were included during this study) in collaborative concept mapping. This system allowed students to make up a message by simply clicking on the appropriate predetermined message (with maybe a little added typing).

Tracking Module

This module could trace the entire process in computer mediated collaborative concept mapping, including dialogue (communication messages) among group members and map products by each group. The system stored these data in its database.

Procedure

The procedure was as follows:

(1) *Grouping.* This study organized subjects into groups of three members. Ten groups were formed. Each group elected a leader to have mapping control. Non-leader members could advise by sending messages.

(2) *Previous Training.* Before starting the formal activity, the subjects received 20-minutes of training on using the system described above. This training included the operations in mapping concepts and synchronously communicating with one another. This training activity arranged the subjects in groups to construct a map with three concept terms (such as "*cerebrum*") and two link terms (such as "*include*").

(3) *Formal Activity.* The subjects were provided 50 minutes to work on their group concept-mapping task. They were told to come to an agreement over any change in their map. This mapping task related to "Computer Hardware." 12 concept terms (such as "*storage equipment*") and 3 link terms (such as "*include*") predefined by primary computer teachers were provided.

Analysis of Computer Mediated Collaborative Concept Mapping

Dialogue messages and map products tracked and recorded by the mapping system were analyzed. The analysis was qualitative in nature. First, dialogue data was examined to categorize the salient features accompanying computer mediated collaborative concept mapping. Further analysis was carried out to realize the structure of the students' concept mapping process. Finally, map data were combined to realize the potential of various collaborative concept mapping processes to improve students' learning.

Findings

Overview of Computer Mediated Collaborative Concept Mapping Process

The basic unit of dialogue is an exchange, which is the set of utterances that serve to achieve some particular mapping purpose. Hence determining the purpose of conversation is an important contribution to classifying an exchange. The exchanges in the dialogue data were divided into four groups. They are:

(1) *Opening a discussion.* At the beginning or to break the silence during developing a concept map, a group member usually opened up a discussion by inviting a more specific discussion of meaning from other members. Normally it was expressed in the form of a question, such as "what shall we do next?" or an invitation, such as "say something, please."

(2) *Introducing a concept.* A group member would introduce a new specific concept to be discussed. After other members' approval (but no proposition content discussion), the mapping controller then selected the concept

from the predefined concept terms. Members would introduce a new concept using a statement, such as "I suggest that we select the *computer hardware* first," or a question, such as "how about *input equipment*□"

(3) *Establishing a Link.* Group members would determine the next link in the concept map in developed form. They would make an utterance to clarify the meaning of a concept pair, propose a link, challenge the proposition, and then would either be in agreement on approving the link or move on to investigate another concept pair. Since only the leader in a group could manipulate the map, the leader might initiate a link without common understanding. Members would raise doubts for discussion.

(4) *Reconsidering the map.* Group members would review their concept map in developed form in terms of the relationships among the concepts, the proposition contents, and the concept hierarchy. If any modification was thought necessary, members (particularly non-leaders, who had no map control) would make a request.

It was found that groups in networked environment repeatedly undertook steps of opening a discussion, introducing a concept, establishing a link, and reconsidering the map to collaboratively developing their concept maps.

Patterns of Computer Mediated Collaborative Concept Mapping Processes

The above analysis indicates that opening a discussion, introducing a concept, establishing a link, and reconsidering the map composed the computer mediated collaborative concept mapping process. However, the processes used by different groups varied. Four patterns were found in this study, described as follows:

(1) *Concept introduction first.* Some groups would first introduce and select most or all of the possible concepts related to the theme for discussion among members. They would then establish the links and reconsider their under-developed map later. This mapping process is shown as (a) in Figure 2.

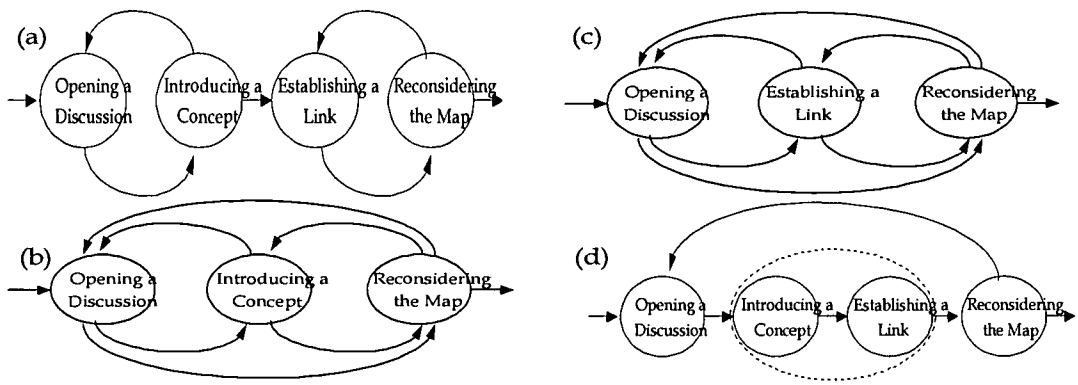

Figure 2: Shows the patterns of computer mediated collaborative concept mapping processes.

(2) *Limited concept introduction.* Group members put more emphasis upon opening discussion, establishing a link, and reconsidering the developed map, but neglected to bring out more new concepts for discussion. Therefore, group members could only focus their discussion on these limited concepts. This mapping process is shown as (b) in Figure 2.

(3) *Less link establishment.* Group members primarily paid attention to the opening discussion, introducing new concepts, and perhaps reconsidering the developed map. Concept elaboration and link establishment were often omitted. Some members might introduce an idea, however others in the group would react by ignoring it, evading it, or recognizing it but moving on. Figure 2 (c) shows this mapping process.

(4) *Proposition construction oriented.* Some groups emphasized proposition construction. A member would directly suggest a term pair, which was thought related or meaningful although vague. Members would then support, explicate, or extend that original idea to generate an approved proposition. While adding a new proposition, members might propose and adjust the organization of the developed map. The process was continued until the group completed its concept map. This mapping process is shown as (d) in Figure 2.

Outcomes from Computer Mediated Collaborative Concept Mapping Processes

Evidence of the outcome of various mapping processes could be provided by the related concept maps in terms of their content and structure and revealed by the scores computed according to a scoring scheme modified from Novak and Gowin's (1984).

(1) *Concept introduction first.* Four groups (G1, G4, G6, and G9) in this study took concept introduction first processes to construct their concept maps. Figure 3 (a) presents a map example produced by these four groups. The average score for these maps was 8.50 (out of 13.00) in terms of proposition, 16.25 (out of 20) in terms of hierarchy, and 24.75 (out of 33.00) in total.

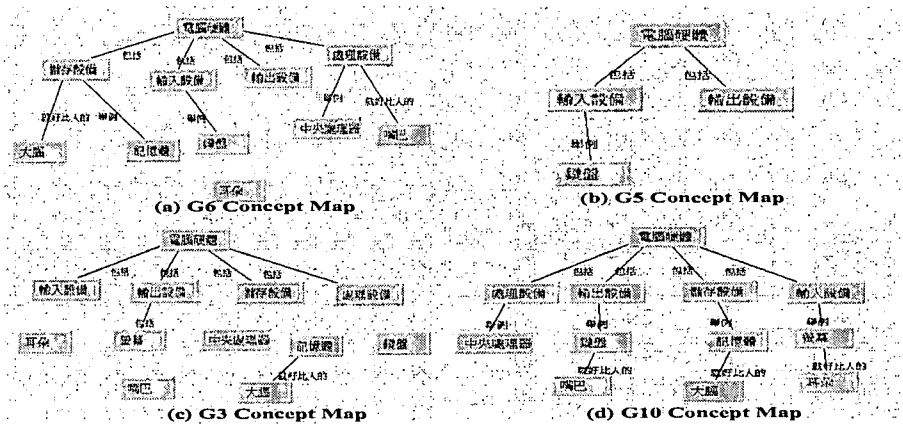

Figure 3: Shows the map examples from various computer mediated collaborative concept mapping processes.

(2) *Limited concept introduction.* One group (G5) in this study took a limited concept introduction process. Figure 3 (b) shows their map. Only a few concepts and propositions were included. This hindered a wider range of discussion. Although the map developed is valid and hierarchical, its score was low, 3.00 on proposition, 8.75 on hierarchy, and 11.75 in total.

(3) *Less link establishment.* Two groups (G2 and G3) in this study used fewer link establishment processes to develop their group concept maps. Many ideas might be raised, but were not discussed further, like their potential relationships. Figure 3 (c) shows an example of their outcomes. Many unconnected concept terms characterized such maps. The average score was 5.50 on proposition, 11.88 on hierarchy, and 17.38 in total.

(4) *Proposition construction oriented.* Three groups (G7, G8, and G10) in this study adopted proposition construction oriented processes to develop their concept maps. Figure 3 (d) shows an example of the generated maps. These maps are satisfying in terms of proposition, validity, and hierarchy. The average score was 10.67 on proposition, 19.44 on hierarchy, and 30.11 in total.

Among the group concept maps produced from the above four mapping processes, maps by the first and forth processes were relatively good in terms of map content and structure. The forth was best, and the second was worst.

Discussion and Conclusion

This study discovered that the process for a group in a networked environment to collaboratively develop a concept map consisted of four main steps: opening discussion, introducing a concept, establishing a link, and reconsidering the map. These steps are similar to those found in paper-and-pencil collaborative concept mapping (Carla, Jos, & Gellof, 1997; Sizmur & Osborne, 1997). In individual concept mapping, regardless if paper-and-pencil or computer based, the reconsideration step was left out. Reader and Hammond (1994) in studying individual computer based concept mapping established this problem, and suggested that automatic feedback be designed into the system to stimulate reflection.

Although computer mediated collaborative concept mapping processes are composed of the same steps, the processes undertook in fact varied in pattern. Students may introduce many concepts, then gradually establish propositions to complete the maps. Student may focus on only a few concepts and find not much to discuss, and thus generate far from complete maps. Some students may introduce many concepts, but neglect to elaborate on their meaning and relationship, and cause the maps to be characterized by independent concept terms. Some students may introduce one or two concepts meaningful to them to generate their first proposition, then progressively expand the maps. In this study, such maps were superior. These findings not only provide an insight into how different process patterns contributed to students' concept maps and their understanding, but are also meaningful as to the design of computer mediated collaborative concept mapping activities and the supporting network system.

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